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COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE

IMPLEMENTATION OF THE RECOMMENDATIONS OF THE SECOND UNITED NATIONS CONFERENCE ON THE EXPLORATION AND PEACEFUL USES OF OUTER SPACE

Basic space science in developing countries

Note by the Secretariat

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INTRODUCTION

1. The Working Group of the Whole to Evaluate the Implementation of the Recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82), in the report on the work of its eighth session, recommended that further studies on space science, technology and applications should be carried out (A/AC.105/571, annex II, para. 17). The Working Group of the Whole

identified a number of possible subjects for such studies, including basic space science in developing countries.

2. The report of the Working Group of the Whole was adopted by the Scientific and Technical Subcommittee at its thirty-first session (A/AC.105/571, para. 22), and the recommendations contained therein were endorsed by the Committee on the Peaceful Uses of Outer Space at its thirty-seventh session[1] and by the General Assembly in its resolution 49/34 of 9 December 1994.

3. A summary of the study on basic space science in developing countries that is being prepared by the Office for Outer Space Affairs in response to the recommendation of the Working Group of the Whole is given in the present note by the Secretariat. The complete study, including an assessment of the series of United Nations/European Space Agency (ESA) workshops on basic space science, will be published in the near future.[2]

SUMMARY OF THE STUDY

A. Background

4. The Committee on the Peaceful Uses of Outer Space was established by General Assembly resolution 1472 (XIV) A of 12 December 1959. The Office for Outer Space Affairs is responsible for implementing decisions of the Committee and its subsidiary bodies relating to the promotion of international cooperation in the peaceful uses of outer space. Among the primary tasks carried out by the Committee are the development of international treaties, conventions and legal principles governing the activities of Member States in the peaceful use and exploration of outer space and the provision of technical assistance and information on space technology and applications to interested Member States.

5. Following the decision of the Committee to promote international cooperation in space science and technology, the United Nations Programme on Space Applications was established with the objective, *inter alia*, of providing scientists from developing countries with educational programmes in remote sensing, satellite meteorology, satellite communication and basic space science. Because of the increasing number of developing countries that are actively engaged in space science research, the United Nations, through the Programme and the Committee, has in recent years placed increased emphasis on promoting education and research in space science and technology and, in particular, planetary exploration and astronomy (topics covered in a guidebook[3] published for International Space Year, 1992), comprising what has come to be known in the international space community as basic space science.

6. Nearly 100 Member States of the United Nations have professional or amateur astronomical organizations. Only about 60 of those States, however, are sufficiently involved in astronomy to belong to the International Astronomical Union (IAU). About 20 States, representing 15 per cent of the world population, have access to the full range of astronomical facilities and information. This does not include most of eastern Europe, the Baltic States and States that constituted the former Union of Soviet Socialist Republics, whose fragile economies keep them from achieving their full potential, despite the excellence of their astronomical heritage and education.

B. United Nations/European Space Agency workshops on basic space science

7. In 1991, as part of the Programme on Space Applications, the United Nations, in cooperation with ESA, initiated the organization of annual workshops on basic space science for developing countries. The workshops were designed to be held as a unique series in each of the following major regions of the world: Africa, Asia and the Pacific, Europe, Latin America and the Caribbean and western Asia. This regional

subdivision follows a United Nations strategy to assess the relevance of space activities to worldwide economic and social development.

8. Six United Nations/ESA workshops on basic space science have been held, as follows: the first, at Bangalore, India, in 1991 (A/AC.105/489); the second, at San José and Bogotá, in 1992 (A/AC.105/530); the third, at Lagos, Nigeria, in 1993 (A/AC.105/560/Add.1); the fourth, at Cairo, in 1994 (A/AC.105/580); the fifth, at Colombo, in 1996 (A/AC.105/640); and the sixth, at Bonn, Germany, in 1996 (A/AC.105/657). The first five workshops were attended by over 300 invited participants from 50 countries and 15 national and international organizations. An assessment of the achievements of the series of workshops was made during the sixth workshop.

9. In 1992, The Planetary Society (TPS) joined the effort to organize the United Nations/ESA workshops in order to provide better coverage of planetary exploration in the programme of the workshops. Between 1991 and 1996, the workshops were also co-organized by the Austrian Space Agency, the *Centre national d'études spatiales* (French National Centre for Space Studies), the German Space Agency, the Institute for Space and Astronautical Science of Japan, the International Centre for Theoretical Physics and the National Aeronautics and Space Administration of the United States of America.

10. The scientific topics covered by the workshops depended on the interests of local organizers and the research activities undertaken in the regions concerned. The topics were chosen from among the following fields: international cooperation in basic space science; education for space science; solar terrestrial interaction; planetary science; space astronomy and astrophysics; cosmology; and databases and on-line data in astronomy.

11. The workshops were hosted by the Governments of the countries in which they were held. The active involvement of government representatives in the organizational and scientific preparations for the workshops ensured close interaction between the Government and the local scientific community. This ultimately proved essential to the achievement of the objectives of the workshops.

12. A vital part of the programme of each workshop consisted in the working group sessions that provided all participants with a common platform to make critical observations and recommendations on the development of astronomy and space science in their respective regions. Those observations and recommendations are contained in the published proceedings,[4, 5, 6, 7, 8, 9] and reflected in the reports on each workshop. The compilation of observations and recommendations provides a unique international framework for the development of astronomy and space science covering the five major regions (and almost all developing countries) of the world.

13. In preparing the programmes of the workshops on a regional basis, the United Nations invited astronomers and space scientists to submit studies on the current status of astronomy and space science in the different regions. Those studies as well as other relevant information are providing a comprehensive picture of the state of basic space science in the developing countries. The work conducted at the workshops has been based on that information, and has led to a number of cooperative international activities in developing countries.

C. Follow-up projects of the United Nations/European Space Agency workshops on basic space science

14. The increasing costs of big science projects and a changing international research atmosphere have fostered the trend in the scientific community to focus on the development of large, internationally funded facilities capable of taking advantage of the climatological and geographical attributes of any country, particularly developing countries.

15. On the other hand, it has been strongly emphasized that the establishment of networks of existing small scientific facilities should also be high on the agenda for strengthening international cooperation, particularly in geomagnetic studies, electrojet current measurements, solar photometry, astrometry, galactic mapping and optical astronomy. A related concept involves international, electronically linked observation programmes, similar to the Whole-Earth-Telescope project, the value of which has become more evident through successful observation runs involving dozens of globally distributed telescopes in recent years. Such programmes could be expanded to include more active participation of developing countries at relatively low cost to them.

16. In addition to the common direct benefits of an international workshop, the United Nations/ESA workshops have generated a number of follow-up projects that are being implemented on a long-term basis.

1. Asia and the Pacific: astronomical telescope facility in Sri Lanka

17. The Government of Japan took the initiative to support the establishment of national astronomical observatories in the region of Asia and the Pacific through the provision of moderate-sized astronomical research telescopes or planetaria. In recent years, Singapore received a Mitaka-kokhi 40-centimetre reflector for its centre for science education, and Malaysia started operating a Minolta planetarium at its centre for space science education. Through the Japanese Cultural Grant Aid Programme, Thailand was able to install a Goto 45-centimetre reflector in the Department of Physics of Chulalongkorn University, Bangkok, and the Bosscha Observatory at Lembang, Indonesia, is using its Goto 45-centimetre reflector for astronomical research.

18. As a result of the First United Nations/European Space Agency Workshop on Basic Space Science, held in India in 1991, the United Nations recommended and supported the establishment of a telescope facility in Sri Lanka. That Workshop and subsequent discussions also led to a donation by the Government of Japan, under the Japanese Cultural Grant Aid Programme, of a 45-centimetre reflecting telescope to Sri Lanka. In 1992, a representative of the Government of Japan visited Sri Lanka and held discussions with many institutions concerning the site for the installation. Considering the heavy expenditure involved, it was decided to install the telescope at the Arthur C. Clarke Centre for the following reasons:

(a) The top floor of a new four-storey building being constructed at the Centre could be modified to host the telescope facility;

(b) The Centre has the capability of handling the repair and maintenance of the fully automated, electronically equipped telescope facility.

19. The telescope facility at the Centre was inaugurated at the Fifth United Nations/European Space Agency Workshop on Basic Space Science, held at Colombo in 1996.

20. Astronomical activities at the Centre are currently handled by its Space Applications Division, set up in 1994 with government approval. The Space Applications Division operates and maintains the telescope facility at the Centre, and has introduced a few programmes to popularize astronomy in Sri Lanka.

21. The Space Applications Division has begun to maintain a database of amateur astronomy societies and astronomical societies in order to meet the needs of Sri Lankan schools for observation facilities. To promote education in astronomy, the Centre will be launching a weekend programme for science teachers in consultation with the Department of Education. The programme will be free of charge, the cost of the training programme being borne by the Centre. Live radio broadcasts of the programme to the rural community have been arranged, as the radio is still the most popular medium of communication in rural Sri Lanka.

22. Since January 1996, the Centre has been organizing observation programmes for science societies and scientific professional institutions in order to promote astronomy among professionals in Sri Lanka.

23. The moderate-sized optical telescopes set up at appropriate locations on Earth have contributed significantly to astronomical research. The Goto 45-centimetre reflecting telescope, for example, is equipped with a photometer, a spectrograph and a photographic camera. Although the telescope was designed primarily for photometric observation studies of variable stars, it also allows for the observation of comets and asteroids and the study of interstellar, interplanetary and atmospheric dust. A network of telescopes of this type throughout a region or worldwide could form an even more powerful tool for other types of astronomical research. Moreover, it could foster regional and international cooperation in astronomical research, as in the case of the Spacewatch programme.

2. South America: Galactic Emission Maps in Colombia

24. At the Second United Nations/European Space Agency Workshop on Basic Space Science, held at San José and Bogotá in 1992, it was stated that the Andean equatorial region offered a combination of geographical attributes, unavailable in other regions of the world, that had great scientific potential for a certain class of observations. Its equatorial latitude and the presence of high peaks (above 4,000 metres) opened up many scientific opportunities. Those characteristics make the region advantageous for observations of the galactic disk (in the radio part of the spectrum) and for observations requiring simultaneous access to both celestial hemispheres. Other classes of experiment, such as automated supernova searches, complemented existing efforts at sites in the northern and southern hemispheres.

25. The need for an accurate determination of the diffuse radio and microwave emission from the galactic disk was highlighted by the limitations imposed on cosmic microwave background data as a result of galactic foreground emission. The Galactic Emission Maps project involves international collaboration (Brazil, Colombia, Italy, Spain and United States) aimed at obtaining an absolute-calibrated multifrequency sky survey in the range of 408 to 5,000 megahertz. A 5.5-metre parabolic reflector equipped with total power radiometers at 408, 1,465 and 2,300 megahertz and with a differential radiometer at 5,000 megahertz has been built, and is being operated at selected sites to achieve maximum sky coverage.

3. Central America: astronomical observatory in Honduras

26. In the early 1990s, Honduras decided to establish the first astronomical observatory in Central America. On the basis of a strategy of regional cooperation between Central American national universities and of contacts at the international level between astronomers and prestigious astronomical research centres, the first steps towards the establishment of the observatory were taken at the Second United Nations/European Space Agency Workshop on Basic Space Science. Since 1994, an astronomical observatory has been functioning at the *Universidad Nacional Autónoma de Honduras* (National Autonomous University of Honduras) at Tegucigalpa. This academic institution has been equipped with a 42-centimetre computerized telescope and other facilities, and is ready to begin a programme for training researchers and technicians from Central America. Several important cooperation agreements are being implemented to promote the development of basic space science in the region.

4. Large astronomical facility for Africa: possibilities for the future

27. As a result of the work of the Third United Nations/European Space Agency Workshop on Basic Space Science, held in Nigeria in 1992, a proposal was drawn up for an Inter-African Astronomical Observatory and Science Park on the Gamsberg in Namibia. Because of its unique geographic location, southern Africa can make an immense contribution to astronomy. Observation of certain time-critical phenomena and 24-hour coverage can be ensured only through astronomical observatories in continents (excluding Antarctica) south of the equator. The Gamsberg has been identified as one of the most suitable sites for an observatory in southern Africa. It is a table mountain 120 kilometres south-west of Windhoek above the Namib desert at an altitude of 2,350 metres above sea level. It experiences a large number of cloudless nights, a dark sky,

excellent atmospheric transparency and low humidity. Comparative test measurements have demonstrated that these qualities are just as good as those of well-known astronomical sites in Chile.

28. The mountain top on the Gamsberg is owned by the Max-Planck-Society of Germany, and a small astronomical station was established there in the 1970s. Besides astronomy, the mountain is of considerable interest to other scientific disciplines such as cosmic ray physics, atmospheric research and meteorology, biology and geology. The huge plateau of about 250 hectares offers enough space for various independent installations.

29. The Max-Planck-Institute for Astronomy at Heidelberg, Germany, is trying to initiate the development of a new scientific centre on the Gamsberg. This can only be achieved, however, through international collaboration and financial and in-kind support. South Africa has expressed an interest in operating the astronomical observatory on behalf of the international community. The ideal solution would be an Inter-African Astronomical Observatory and Science Park. The Government of Namibia, as well as the recently established Windhoek University, have expressed support for the project. If established, the facility could become an important focus for the development of basic space science in African countries. If provided with a viable infrastructure, it could be attractive to countries in the northern hemisphere as well, especially those wishing to establish facilities in the southern hemisphere.

5. Western Asia: Kottamia Observatory in Egypt

30. In conjunction with the Fourth United Nations/European Space Agency Workshop on Basic Space Science, held at Cairo in 1994, it was decided to refurbish the Kottamia telescope. The National Research Institute for Astrophysics and Geophysics (NRIAG) at Helwan and the Ministry of Scientific Research entered into a contract financed by the Government of Egypt. The project included the design and manufacture of a new optical system for the 1.88-metre telescope tube. The mirror materials were made from schott zerodur to ensure superb optical quality in the temperature range for observations. In order to achieve a high-quality optical surface in all applicable positions of the telescope, a new support, or mirror cell, for the primary mirror will be necessary. A new 18-point support instead of the old nine-point support has been proposed, and will become part of the project. The new optics will be integrated into the nearly 30-year-old Kottamia telescope, and first light is expected in early 1997. In July 1995, the representatives of NRIAG accepted the results of the tests of the blanc for the primary mirror at a factory in Germany. The mirror was still being ground and polished, resting on an 18-point support just as in the future telescope cell. The procedure was to take several months, first creating a surface of high quality and then gradually approximating the required spherical shape. Preliminary tests of the mirror shape showed excellent results, and the preliminary acceptance tests were to be carried out on schedule in 1996.

6. Contribution of Egypt to the United States/Russian Federation Mars mission scheduled for 2001

31. During the Fourth United Nations/European Space Agency Workshop on Basic Space Science, the possible participation of Egypt in a future Mars Rover Mission was discussed. One suggestion was that Egypt participate in the Mission through the design, building and testing of a drill for obtaining subsurface samples.

32. TPS, a sponsor of the series of United Nations/ESA workshops, is following up that suggestion. TPS representatives, together with Egyptian scientists, have begun organizing a study of the concept. They informed the Space Research Institute of the Russian Academy of Sciences about the idea, and the Institute, in turn, formally invited the Ministry of Scientific Research of Egypt to study the concept for potential use on the Russian Mars 2001 Mission. Such a study has already begun.

33. Inclusion of a sort of drilling mechanism in the payload of such a mission would assist scientists in the investigation of volatile organic materials and mineralogy. Twenty years ago, the Viking Mars lander was

able to obtain samples from depths of up to 10 centimetres. Today, a drill with the capability of boring more than 1 metre would be essential to further research and investigation.

34. Egypt has expertise in drill development. A few years ago, as part of the archaeological exploration of the Pyramids, a sophisticated drilling system was developed to drill into a subsurface chamber and deploy a camera without allowing air into the chamber. The drill perforated the limestone to a depth of two metres without the use of lubricants or cooling fluids that might have contaminated the environment of the pit, and successfully collected six samples.

35. The above-mentioned experiment and other more common terrestrial applications suggest that the necessary technology base for drill development can be brought together in the Russian Mars 2001 Mission.

36. A study team of Egyptian scientists, collaborating with Russian Federation, United States and European scientists, has been established.

D. Worldwide network of telescopes for observing Near-Earth Objects

37. The recent impact of the Shoemaker-Levy 9 comet on Jupiter has raised new concerns about the possibility of a Near-Earth Object hitting Earth. Pursuing an understanding of the interactions of Earth with Near-Earth Objects has become an issue of global importance.

38. In an effort to provide a scientific basis for future cooperative international research and space exploration, The Explorers Club and the Office for Outer Space Affairs recently organized an International Conference on Near-Earth Objects,[10] held in New York from 24 to 26 April 1995. Leading researchers in the fields of astronomy, planetary science, astrophysics, paleontology and astronautics assembled from around the world to present their ideas on various related topics. The programme of the Conference included interdisciplinary aspects of Near-Earth Objects from the point of view of natural science.

39. Among the topics dealt with by the Conference was the establishment of adequate observational facilities for Near-Earth Objects in both the northern and southern hemispheres. As a first step, improvements in existing astronomical telescope facilities, including those in developing countries, should be undertaken. Observation programmes could then be coordinated with the activities of amateur astronomy groups and organized at the international level, which might lead to the establishment of a network of moderate-sized astronomical telescopes as discussed at United Nations/ESA workshops on basic space science (A/AC.105/640 and A/AC.105/657).

E. Conclusion

40. The observations and recommendations made during the six United Nations/ESA workshops on basic space science may be summarized and presented as topics that need to be urgently dealt with on a regional basis, under the following headings:

(a) Promotion of the advancement and dissemination of knowledge of basic space science and its application to human welfare;

(b) Provision of on-line databases and e-mail services;

(c) Provision of abstracting and indexing services in basic space science;

(d) Dissemination of reliable information on basic space science to the public;

(e) Collection and analysis of statistics on basic space science as a profession and as a branch of education;

(f) Encouragement of the documentation and study of the history and philosophy of basic space science;

(g) Cooperation with organizations on educational projects at all levels.

41. Among the above-mentioned topics, the electronic networking of scientific institutions may have the most immediate impact on the situation in developing countries. Extensive data archives on space science are readily available at virtually no cost to any astronomer who has access to the Internet. Space astronomy missions such as the Cosmic Background Explorer, the Hubble Space Telescope, the Infra-Red Astronomical Satellite, the International Ultraviolet Explorer and the Roentgen Satellite have made their data archives publicly accessible through electronic networks. Those archives are available to astronomers in any country on Earth, provided they have access to the Internet. Electronic networks also allow immediate access to electronic mail channels and electronic publications (Astrophysical Data System), solving the traditional problem of isolation and obsolete libraries in many developing countries. The combined efforts of individual astronomers and the support of Governments and international organizations could assist in achieving the goal of a global village based on worldwide education and research in basic space science.

Notes

[1] *Official Records of the General Assembly, Forty-ninth Session, Supplement No. 20* (A/49/20), para. 29.

[2] *Developing Astronomy and Space Science Worldwide* (United Nations, forthcoming).

[3] Office for Outer Space Affairs, *Planetarium - a Challenge for Educators* (New York, 1992).

[4] "Basic space science: proceedings of the Fourth United Nations/European Space Agency Workshop", *Earth, Moon, and Planets*, vol. 10, Nos. 1-3 (1995).

[5] "Basic space science: proceedings of the Fourth United Nations/European Space Agency Workshop", *Astrophysics and Space Science*, vol. 228, Nos. 1 and 2 (June 1995).

[6] "Basic space science: proceedings of the Third United Nations/European Space Agency Workshop", *American Institute of Physics Conference Proceedings*, vol. 320, 1994.

[7] "Basic space science: proceedings of the Second United Nations/European Space Agency Workshop" (San José), *Earth, Moon, and Planets*, vol. 63, No. 2 (November 1993).

[8] "Basic space science: proceedings of the Second United Nations/European Space Agency Workshop" (Bogotá), *Astrophysics and Space Science*, vol. 214, Nos. 1 and 2 (April 1994).

[9] "Basic space science: proceedings of the First United Nations/European Space Agency Workshop", *American Institute of Physics Conference Proceedings*, vol. 245, 1992.

[10] "Near-Earth Objects: the United Nations International Conference", *Annals of the New York Academy of Sciences*, vol. 850, 1996.